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(54) **Friction clutch with clutch wear displacement sensor in or on slave cylinder**

(57) A friction clutch (1, Fig. 1) for a motor vehicle is actuable via a system comprising a hydraulic master cylinder (2, Fig. 1) and slave cylinder (3, 4, 5; Fig 1) having a displacement sensor, which determines the clutches state of wear, combined with the slave cylinder to form a unit. The slave cylinder may be arranged outside the clutch and connected by a release rod (7, Fig. 1). Alternatively the slave cylinder may be combined with the release bearing 6 to form a unit arranged around gear shaft 1b. The displacement sensors may be a mechanical/electrical limit switch 22, 29, a hydraulic pressure-operated switch (23, Fig. 5) or a displacement sensor, eg variable resistor (37, 38; Fig. 7). Both arrangements of slave cylinder may be provided with a limit switch and displacement sensor, but only the outside arrangement may be provided with the pressure switch (23, Fig. 5). A displacement sensor of this type does not necessitate constructional modifications to the clutch and is only slightly affected by tolerances of the release system.

Fig. 6

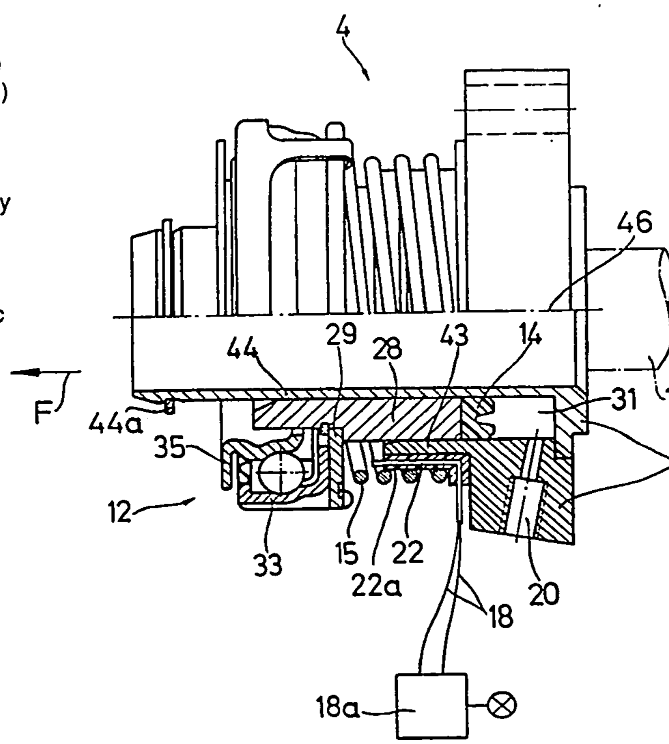

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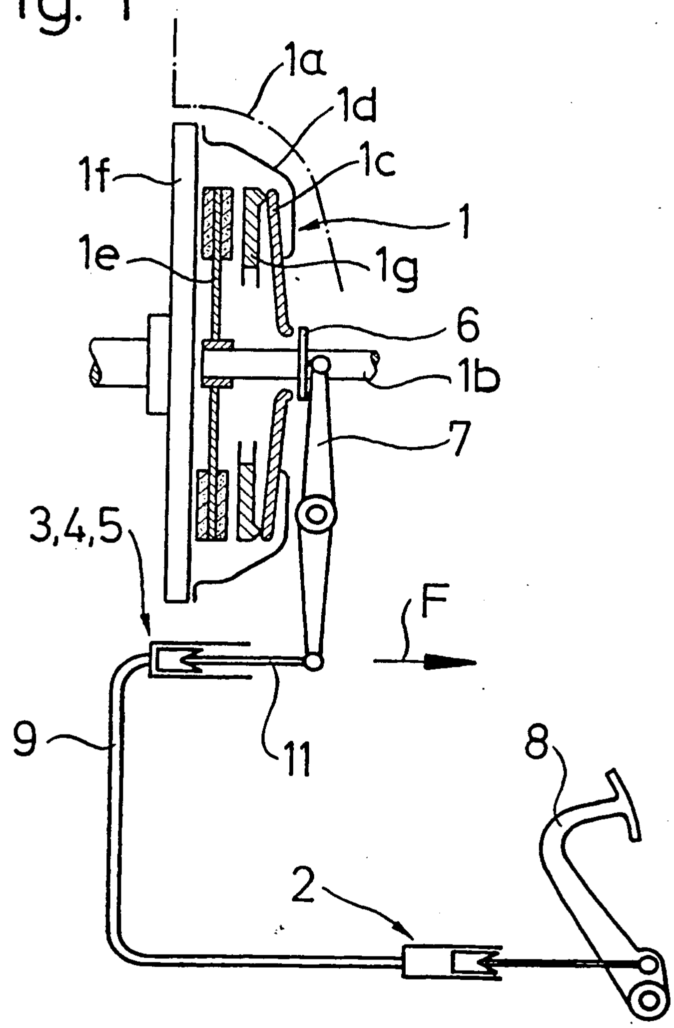
Fig. 1



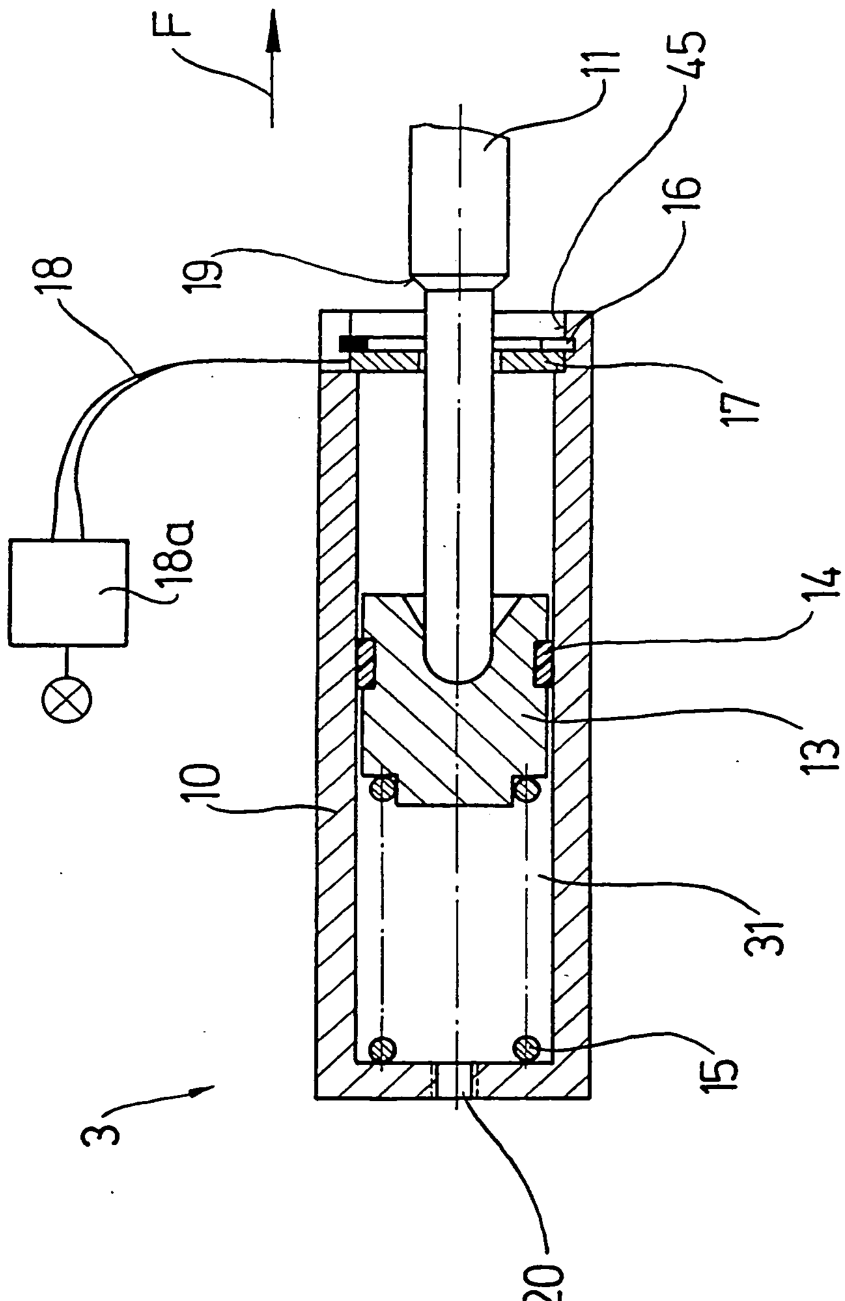


Fig. 2

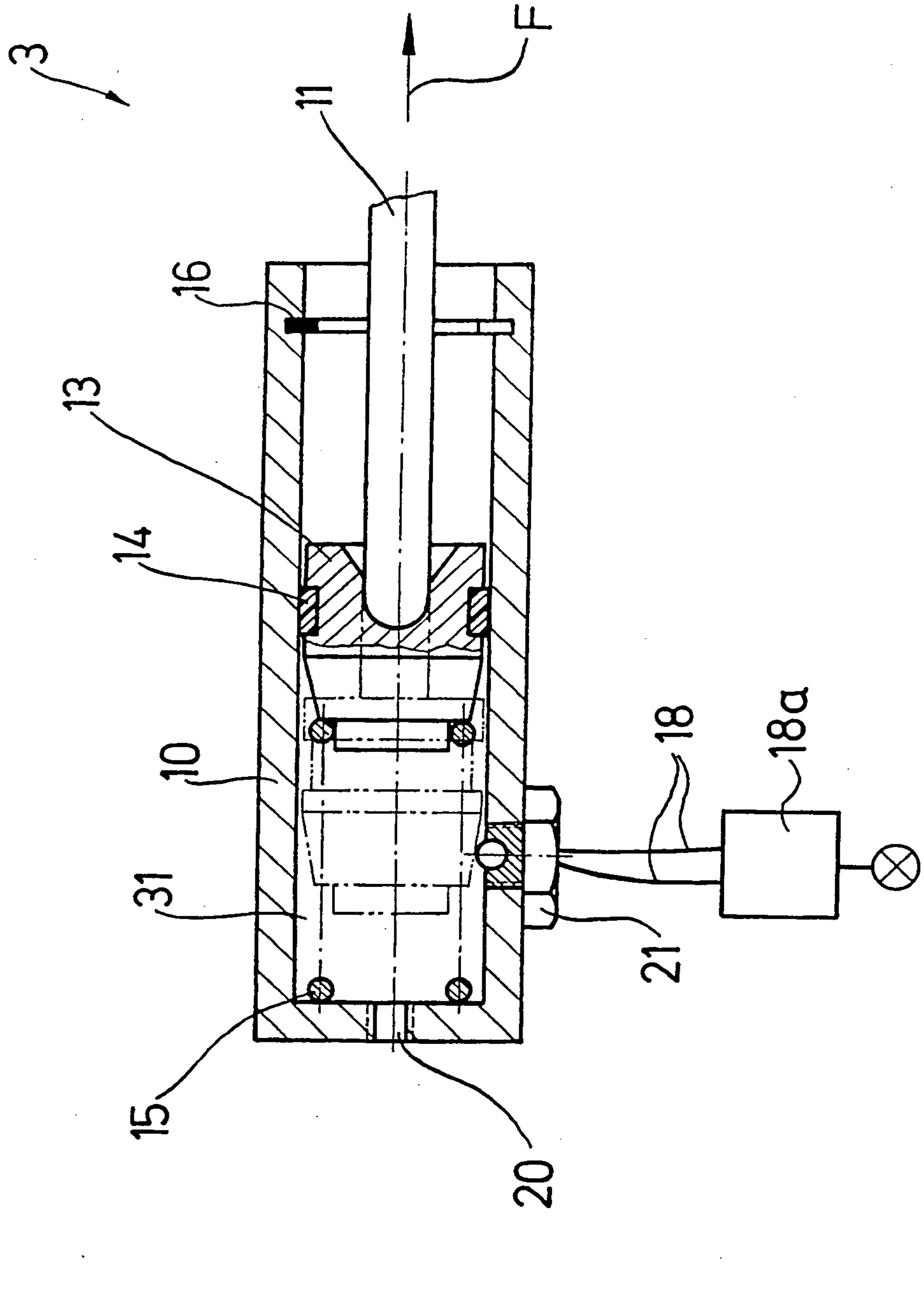
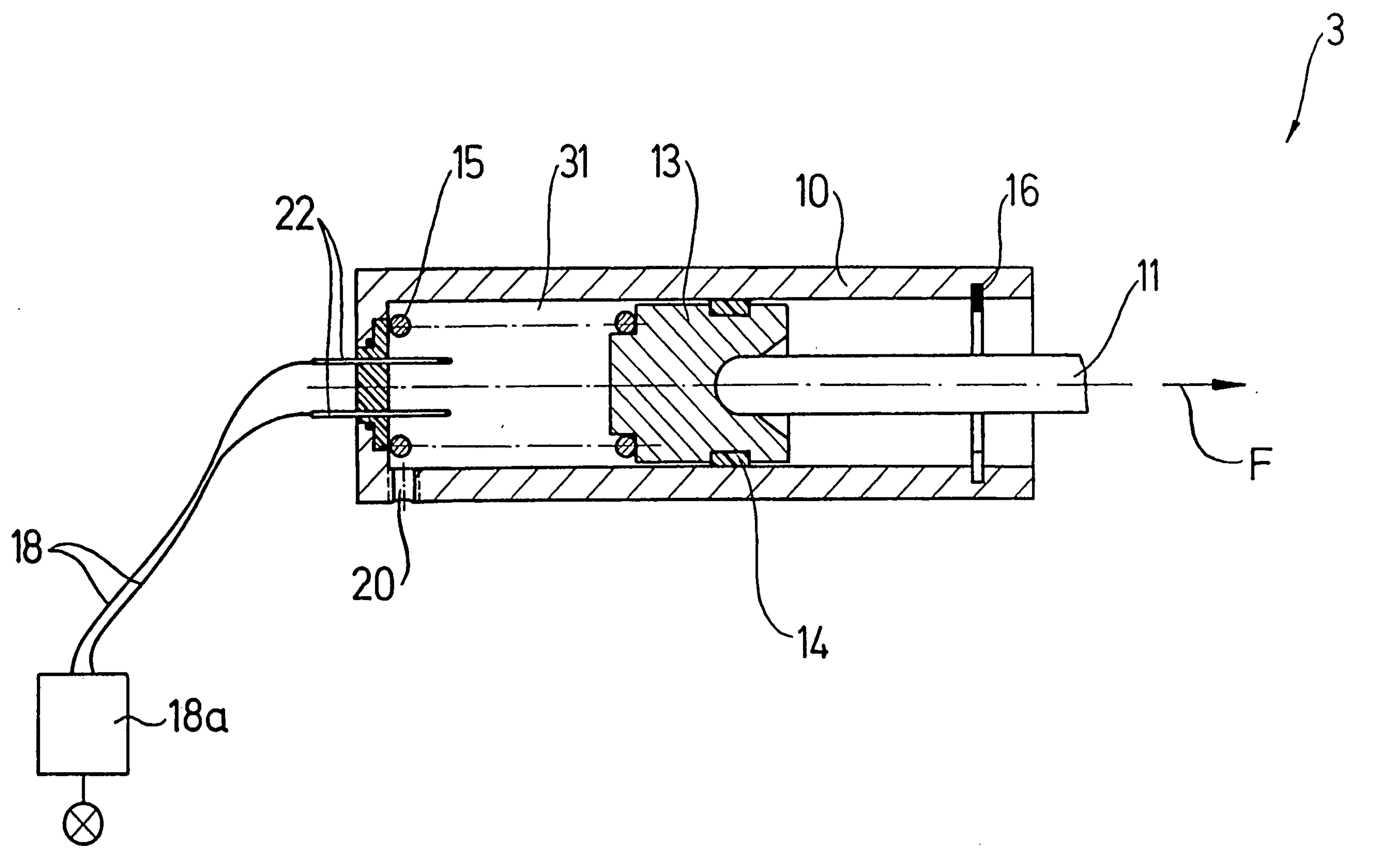


Fig. 3

Fig. 4



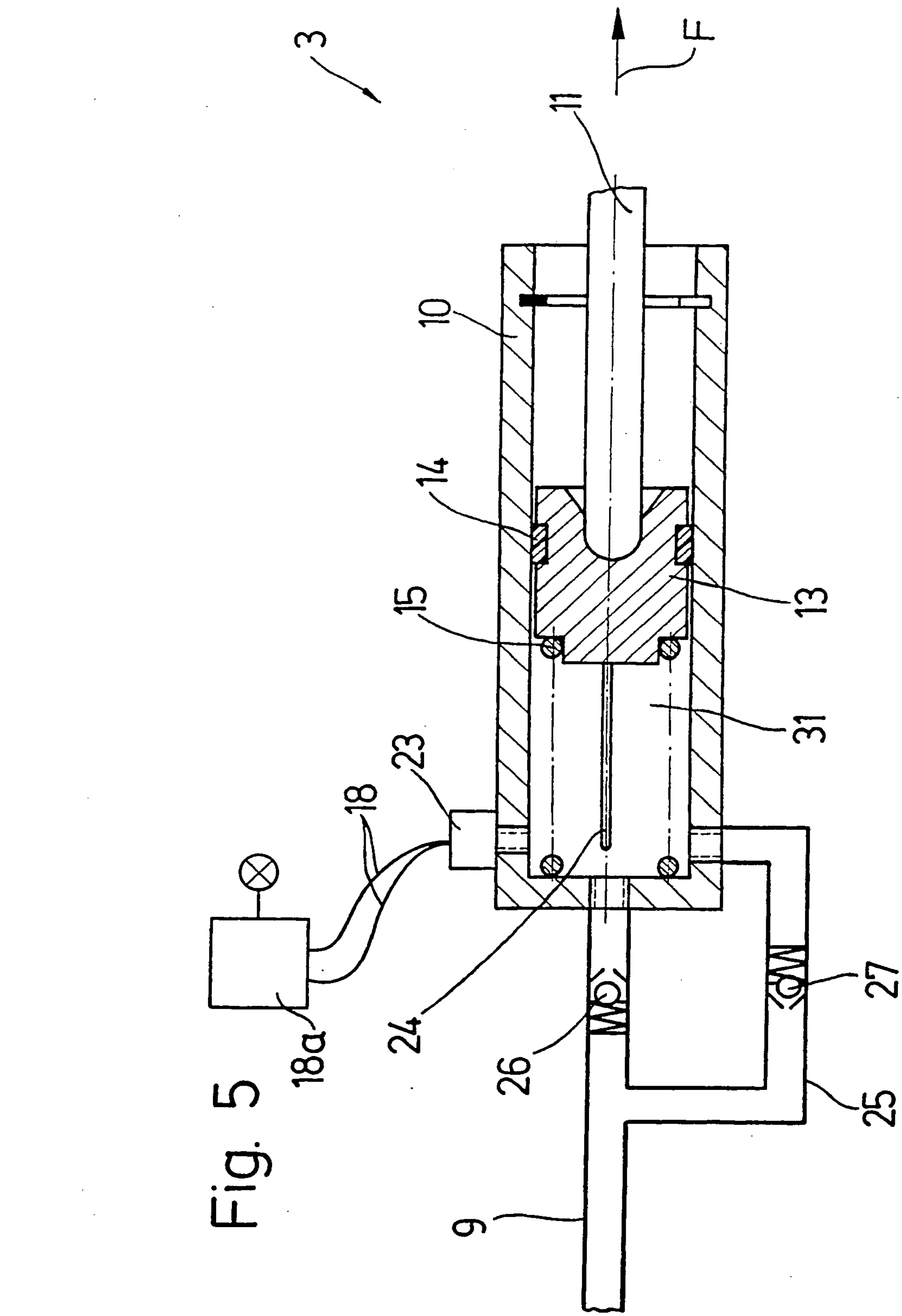


Fig. 5

Fig. 6

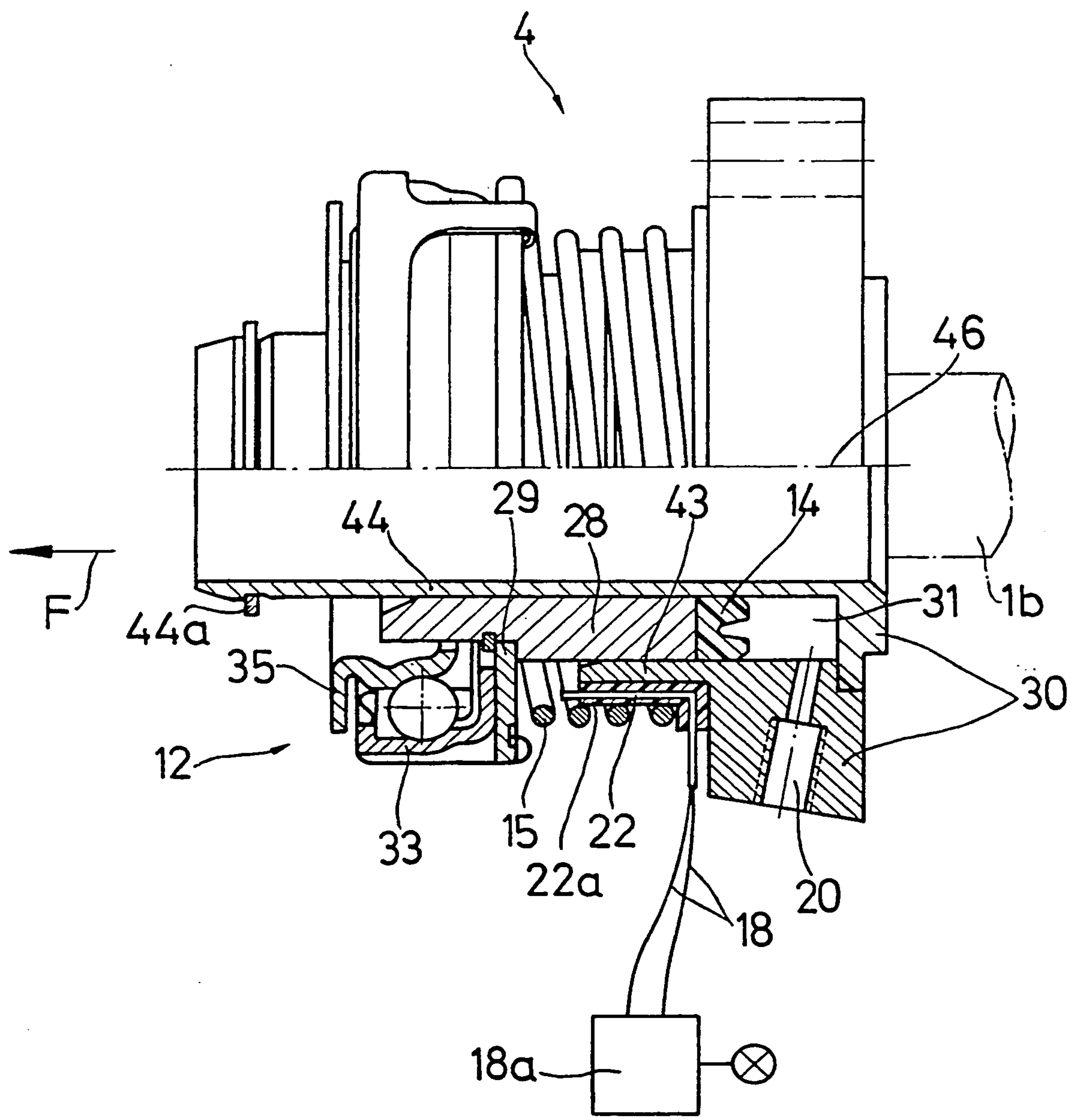


Fig. 7

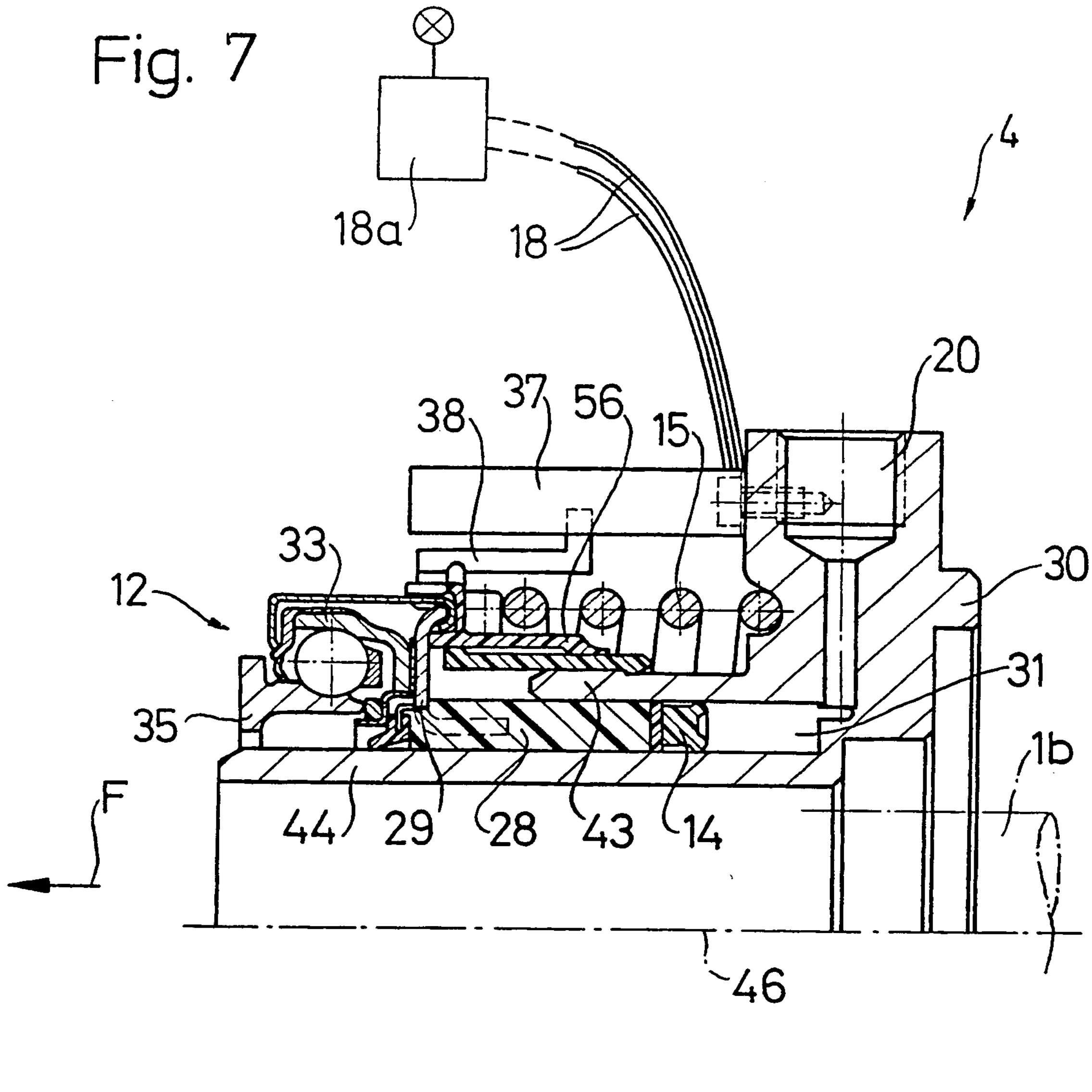


Fig. 8

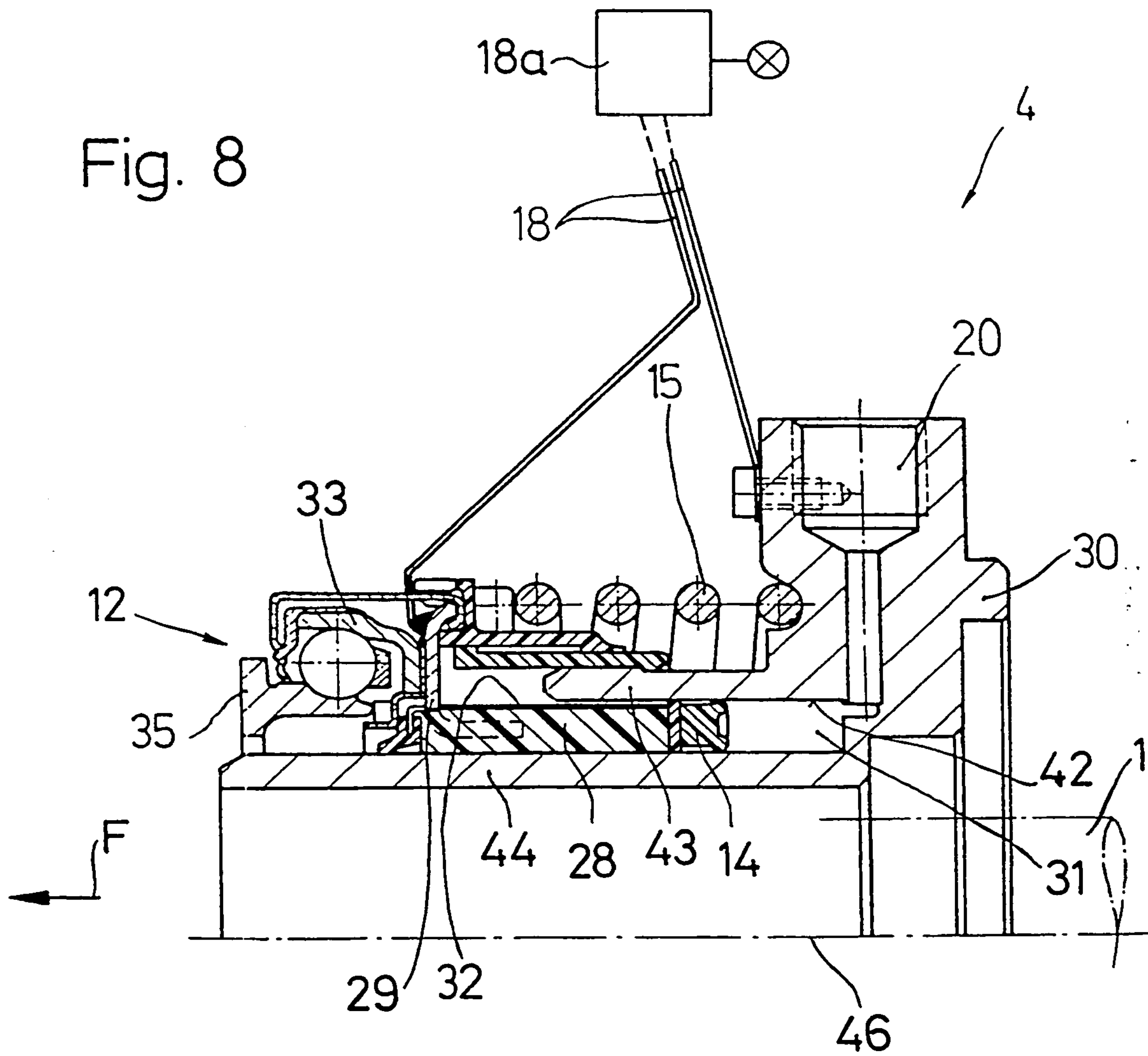
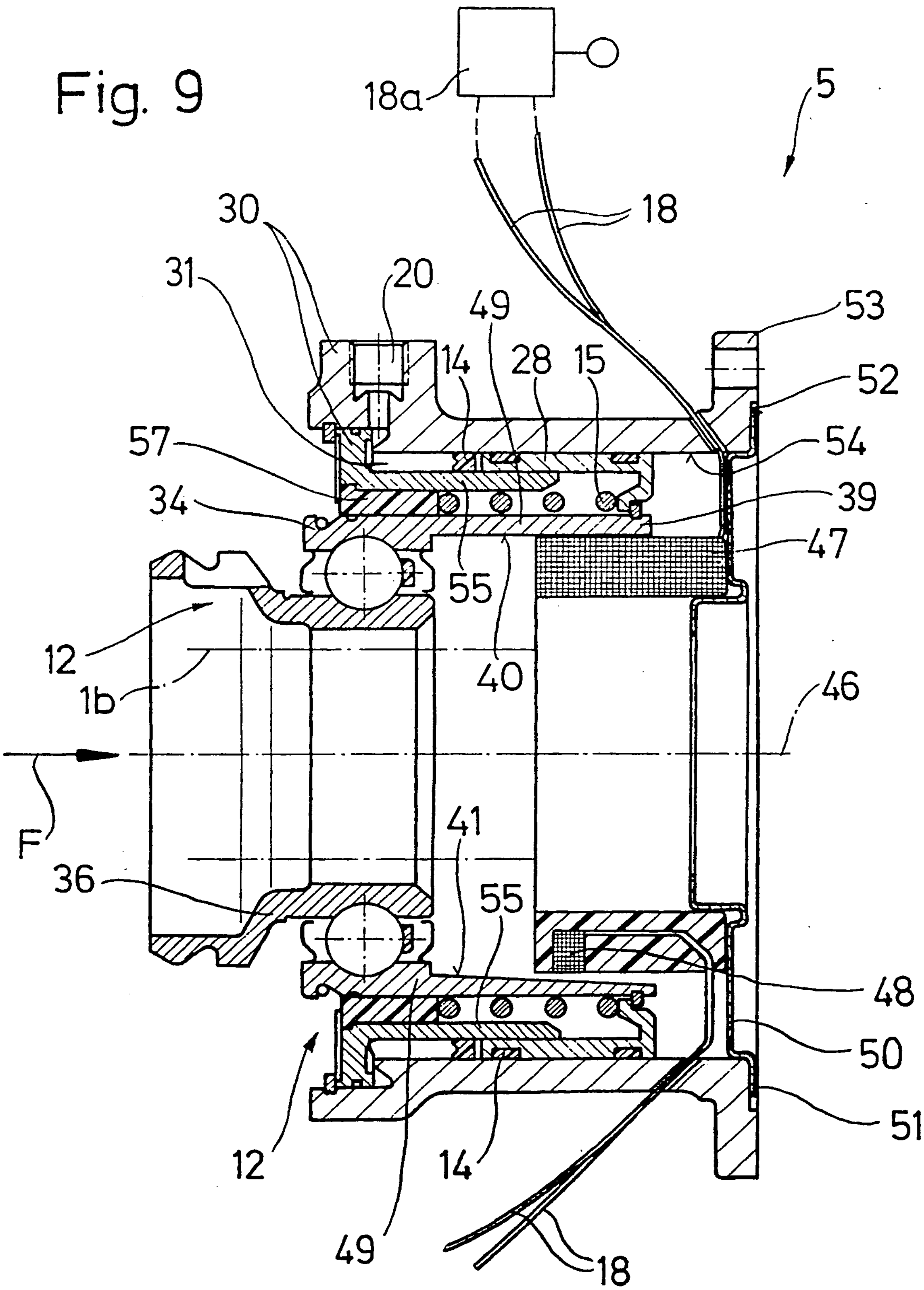


Fig. 9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FRICTION CLUTCH WITH DISPLACEMENT SENSOR

The invention relates to a friction clutch for motor vehicles with a clutch plate which may be fixed between two components and rests non-rotatably on a gear shaft, a clutch spring for fixing the clutch plate between the two components, a clutch actuator with a clutch-side slave device, a clutch-remote master device as well as an interposed transmission device, a displacement sensor being arranged in the clutch-side slave device.

A device is known from German patent 2916 807 in which the state of engagement of a friction clutch may be measured directly via a proximity switch in the flywheel. However, the arrangement is very expensive, it has to be provided in advance in important components of the internal combustion engine and the transmission of the signal from the rotating component is problematic. A central releasing device is also known from German Offenlegungsschrift 3912 431 which is provided with sensors for detecting the speed of rotation of the gear shaft and for detecting the state of wear of the friction clutch.

It is proposed that the gear shaft be provided with separate teeth which have to be axially conical in design when used as a displacement sensor. In a further embodiment, the sensor moves relative to a revolving casing part which also has to have a specific shape.

An object of the present invention, with a conventional friction clutch, is to allow a statement about the state of wear of the clutch at any time in order thus to avoid, for example, significant follow-up costs. It is also to be possible to determine the state of engagement of the clutch to allow clutch actuation to be controlled to the desired extent in automated friction clutches.

According to the invention there is provided a friction clutch for a motor vehicle with a clutch plate which may be fixed between two components and rests non-rotatably on a gear shaft, a clutch spring for fixing the clutch plate between the two components, a clutch actuator with a clutch-side slave device, a clutch-remote master device as well as an interposed transmission device, a displacement sensor being arranged in the clutch-side slave device, characterised by the following features: (a) the clutch actuator contains a fluid-actuated slave cylinder; (b) the displacement sensor is arranged in or on the slave cylinder.

By using a fluid-actuated slave cylinder on the one hand and connecting the displacement sensor in or on the slave cylinder to form an independently manageable unit it is possible to combine the advantages of clutch actuation *via* a fluid with the advantages of displacement measurement as close as possible to the clutch without having to allow for the disadvantage that interventions have to be carried out on conventional clutch components merely on account of the arrangement of the displacement sensors. The arrangement of the displacement sensor in or on the slave cylinder results in particularly simple handling during assembly.

The slave cylinder may be arranged outside the clutch and may be connected to the releasing device *via* a release rod. Such a design is useful if an existing clutch system is to be converted to hydraulic actuation with minimum expenditure. The slave cylinder is fastened and supported, for example on the casing, e g of the gear, surrounding the clutch and it acts upon a rod extending directly to the release device.

A design in which the slave cylinder is combined with the release bearing to form a unit arranged concentrically round the gear shaft is particularly advantageous. In this case, the displacement sensor rests in the immediate vicinity of the release bearing and it operates independently of the losses or elasticities which may occur up to the slave cylinder.

The displacement sensor may be designed as a conventional commercial component in the form of a mechanical/electrical limit switch. It is actuated when the wear limit for the friction linings of the clutch plate is reached.

However, it is also possible to design the displacement sensor as a hydraulic pressure-operated switch. Such a solution is particularly attractive as it is based on the behaviour of the hydraulic pressure as a measured variable.

According to the invention, the displacement sensor may be designed to produce a digital displacement signal. Such digital displacement detection is particularly advantageous if clutch actuation is monitored by an electronic controller. However, it is also directly possible to provide the displacement sensor with an analog measuring device which may consist, for example, of a variable resistor, a variable capacitor or a variable inductor. The arrangement of the displacement sensors and the choice of their mode of operation will be based, for example, on the physical parameters and possibilities for arrangement.

In a constructionally very simple solution, the limit switch is fastened on the casing of the slave cylinder and is actuated by a part which is movable relative to the casing and communicates with the release system. The inaccuracies which may occur between the master cylinder and the slave cylinder are eliminated by such an arrangement. A limit switch of this type may be designed, for example, as an exchangeable resistance element which is connected to a display circuit and is destroyed by the movable part when the limit of wear of the friction linings of the clutch plate is reached.

The display circuit is thus influenced in a simple manner and delivers a signal which indicates to the user that the limit of wear has been reached. The display circuit may be brought back to the new state in conjunction with the overhaul of the clutch merely by exchanging this resistance element.

With a slave cylinder designed separately from the release bearing and having a cylindrical casing and with a piston capable of moving in a bore in this casing, an annular disc-shaped resistance element of which the opening is penetrated by the piston rod may be arranged on the casing in the region of emergence of the piston rods from the casing. A diametral enlargement arranged on the piston rod forms an edge which destroys the resistance element at an appropriate wear position. Such a resistance element is a very inexpensive component which may also easily be exchanged again after being destroyed. It can have an at least partially curved external contour corresponding to a hollow in the casing and can be held there between a step and a securing ring.

A limit switch which is actuated directly by the piston may however also be installed in a slave cylinder which is separate from the release bearing. The limit switch extends directly into the pressure chamber formed between piston and casing and it is actuated by the end region, facing the pressure chamber, of the piston. Such an arrangement has the advantage that the limit switch is arranged in a protected manner and cannot be exposed to damage from the exterior.

The limit switch may be inserted tightly into the cylindrical casing radially from the exterior and may penetrate into the pressure chamber. In such a case, the limit switch may also easily be exchanged in the case of a possible defect.

However, the limit switch may also easily be formed by two contact pins which are arranged in parallel, are insulated in the wall which opposes the piston and seals the pressure chamber, extend toward the piston, are connected to a display circuit and are conductively interconnectable by the electrically conductive surface of the piston. Such a design can be achieved at low cost, the piston having to be electrically conductive and therefore consisting either

completely of a conductive material or at least its end face being provided with a conductive covering. Such an arrangement is simple and reliable in operation, and the cables leading away from the contact pins merely have to be connected to the evaluating or control device.

The arrangement of two contact pins extending parallel to the axis may also be employed with a release system in which the slave cylinder is arranged concentrically round the gear shaft and has a fluid-actuated annular piston which carries a release bearing on one side and forms a pressure chamber with the casing on the other side, wherein the contact pins are fastened in an insulated manner on the casing, are connected to a display circuit and may come to rest on electrically conductive parts of the release bearing or of its mounting. Such an arrangement is of interest, for example if an already existing releasing device is subsequently to be equipped with a limit switch.

In particular with a slave cylinder which is separate from the releasing device, it is also possible to display a pressure drop via a pressure-operated switch which penetrates, for example, into the pressure chamber. For this purpose, the slave cylinder is provided with two pressure lines, a nonreturn valve being arranged in each pressure line, more specifically so as to act in opposite directions to one another. One nonreturn valve is designed as a residual pressure valve and provides for a residual pressure of a predetermined value in the pressure chamber. This residual pressure valve may be opened by the piston or by a component connected to the piston when the wear position is reached so that the residual pressure drops to zero.

This pressure drop may be displayed via the hydraulic pressure-operated switch. Such evaluation of the residual

pressure is very attractive if all mechanically movable parts are arranged in the pressure medium.

A further desirable design according to the invention for determining the release movement arises with a slave cylinder arranged concentrically round the gear shaft in that the already existing components are used to achieve, as a function of the release state, a variable overlap of which the size may be measured via induction or capacitance variation. Thus, for example, a piston produced from an electrically non-conductive material may be provided on its external periphery with an electrically conductive layer, with this layer may be at a distance from the internal contour of an axial projection of the casing, more specifically such that the axial projection is partially overlapped by the piston and a variable capacitance arises between piston surface and internal contour as a gauge of the release movement. Such a construction uses already existing components for monitoring the axial movement of the releasing device relative to the casing via variations of capacitance.

However, it may also be advantageous to provide as a component which is rigid with the casing an induction coil which is axially overlapped to different extents according to the state of release by a ferromagnetic component of cylindrical contour, the variation of inductance being evaluated as a gauge of the release path. A different axial overlap may be employed, on the one hand, as a means of comparison, but it is also possible for the ferromagnetic component to have a conical contour so that radial path variation between the induction coil and the conical surface may be measured via the axial release displacement. In particular during the actuation of a so-called drawn clutch by the slave cylinder, an advantageous arrangement for the induction coil is achieved in that the ferromagnetic component is designed as a tubular portion which is connected

at least positively at one end region to the annular piston and of which the opposite end region has an antifriction bearing track of the release bearing.

This allows the release bearing to be arranged in one end region of the tubular portion and the induction coil in the other end region. The space for the induction coil need not therefore be provided first of all.

According to the invention, the induction coil may be fastened on a sheet metal carrier which is radially fixed on an annular cylindrical internal contour of the casing which simultaneously serves to guide the annular piston, the sheet metal carrier being axially fixed in a hollow of the fastening flange of the casing by a radially angled collar. This results in very simple assembly and fastening of the induction coil.

In a further advantageous design of the slave cylinder with central arrangement around the gear shaft, the annular piston is provided, on the side opposite the pressure chamber, with a radial flange on which the non-revolving bearing ring rests from one side and a bias spring resting on the casing on the other side, a sensor being fastened radially outside the bias spring on the casing and extending axially toward the release bearing, a slider which performs a relative movement with respect to the sensor according to the release movement of the piston also being arranged on the flange. A concentric releasing device may therefore be provided with a displacement sensor quite simply even at a later stage in this way. A displacement sensor which delivers both analog signals and digital signals and is connected via a corresponding connecting line to a central controller may be used. In a design in which a dustproof sleeve is arranged between an axial casing projection and the supporting plate for the release bearing, the slider may advantageously be

fastened radially outside the bias spring on the dustproof sleeve. This dustproof sleeve is held in constant contact on the supporting plate by the bias spring. The slider may thus be arranged without intervening in the basic components of the slave cylinder.

The invention is described in more detail hereinafter with reference to several embodiments.

Figure 1 is a basic diagram of a fluid-actuated friction clutch.

Figure 2 is the longitudinal section through a slave cylinder with a destructible resistance element.

Figure 3 is the longitudinal section through a slave cylinder with a piston-actuated switch.

Figure 4 is the longitudinal section through a slave cylinder with contact pins arranged in one end wall.

Figure 5 is the longitudinal section through a slave cylinder with a hydraulic pressure-operated switch and a residual pressure valve.

Figure 6 is the longitudinal section through a slave cylinder arranged concentrically round the gear shaft with the arrangement of two contact pins.

Figure 7 is the longitudinal section through a concentric slave cylinder with an externally mounted sensor.

Figure 8 is the longitudinal section through a concentric slave cylinder with capacitive displacement detection.

Figure 9 is an upper and a lower longitudinal section through a concentric slave cylinder with two different displacement measuring devices on an inductive basis.

Figure 1 shows the basic construction of a fluid-actuated friction clutch 1. Starting from a clutch pedal 8, a master cylinder 2 is directly loaded which is connected via a pressure line 9 to one of the slave cylinders 3, 4 or 5 described hereinafter, this slave cylinder being rigidly arranged on a casing 1a, for example a bell of the gear casing, which surrounds the friction clutch and acting via a piston rod 11 upon a release fork 7 which acts in the interior of the casing 1a directly upon the releasing device 6. This releasing device 6 is arranged concentrically to a gear shaft shown at 1b and it acts upon the release elements of the friction clutch 1. These release elements may be designed, for example, in the form of tongues of a diaphragm spring 1c or also as individual levers pivotally mounted on the friction clutch 1. The diaphragm spring 1c mounted on a clutch casing 1d in the conventional manner tensions a clutch plate 1e held non-rotatably on the gear shaft 1b between a flywheel 1f and a pressing plate 1g which is non-rotatably but axially movably guided relative to the flywheel 1f. Master and slave cylinder as well as the pressure line 9 are preferably filled with a hydraulic fluid which is substantially incompressible. Loss-free power transmission from the clutch pedal 8 to the releasing device 6 is permitted in this way. During actuation of the clutch pedal 8, the clutch pedal 8 is pivoted in an anticlockwise direction round a pivot point so that the piston in the master cylinder 2 moves the actuating fluid through the pressure line 9 and the piston in the slave cylinder moves the piston rod 11 in the direction of the arrow F so that the release fork 7 is pivoted in an anticlockwise direction and the releasing device 6 ventilates the friction clutch 1. All movements take place in the opposite direction when the

clutch pedal 8 is released. If the friction clutch 1 is a so-called drawn friction clutch, the pivot point of the release fork 7 is on the side opposite the releasing device 6 from the point of view of the piston rod 11. Therefore both the piston rod 11 and the releasing device 6 move in the direction of arrow F during the releasing process.

The actuation of the friction clutch 1 may also take place automatically. In that case, an electric motor drive which is controlled by an electronic control system and loads the master cylinder 2 in an appropriate manner is provided instead of the clutch pedal 8. To enable the state of engagement of the clutch to be checked at any time in the case of an electric motor-actuated friction clutch and to establish whether the limit of wear of the friction linings of the clutch plate of the friction clutch has been reached, a displacement sensor is arranged on the slave cylinder in the manner described hereinafter and - in a simple design merely displays the state of wear when the limit of wear is reached or is able to detect and check the position of the release system and therefore the engagement position of the clutch as well as the state of wear in particular with a view to automatic clutch actuation. The arrangement of this sensor on the slave cylinder allows particularly exact determination of the respective release state in that the elasticities in the system from the clutch pedal 8 or from the electric motor loading of the master cylinder 2 to the slave cylinder has no effect. With an arrangement according to Figure 1, the slave cylinder is fastened, for example, on the stationary casing 1a surrounding the friction clutch 1 and it acts via the release fork 7 upon the releasing device 6. Such a construction is useful if as many parts as possible of an existing clutch construction are to be adopted. However, it is also directly possible to arrange the slave cylinder directly concentrically to the gear shaft on the release elements of the friction clutch in which case

only the pressure line 9 has to be guided into the interior of the casing. Such a construction avoids the interposition of intermediate elements such as the release fork.

Several embodiments of slave cylinders provided with a displacement sensor are described in detail hereinafter. Thus, Figure 2 is a longitudinal is a longitudinal section through a slave cylinder 3 consisting of a cylindrical casing 10 in which a piston 13 is movably arranged. The casing 10 forms a pressure chamber 31 with the piston 13 on one side, and a piston rod 11 which extends from the piston out of the casing 10 and is connected there to the release fork 7 according to Figure 1 is arranged on the other side. A bias spring 15 which acts between the piston 13 and a casing wall is arranged in the pressure chamber 31. It ensures permanent easy contact of the releasing device 6 on the release parts of the friction clutch 1. The pressure chamber 31 is connected via a connection 20 to the pressure line 9 leading to the master cylinder 2. The piston 13 is sealed from the internal wall of the casing 10 via seals 14.

A resistance element 17 which is held axially by a shoulder in the casing 10 and by a securing ring 16 is arranged in a hollow 45 at the end region, adjacent to the piston rod 11, of the casing 10. During release of the clutch, the piston 13 is moved to the right in the direction of arrow F by the supply of hydraulic medium into the pressure chamber 31 and during engagement of the clutch a movement takes place in the opposite direction. When the friction linings of the clutch plate 1e (Figure 1) in the friction clutch are worn, the entire system consisting of releasing device 6, release fork 7 and piston rod 11 shifts to the left in the course of time against the direction of arrow F. Owing to the arrangement of an edge 19 on the piston rod 11, the edge 19 destroys the resistance element 17 as a result of the backward movement of the piston rod 11 when the limit of wear of the friction

linings is reached, if the displacement conditions are appropriately allocated. The electrical resistance of the resistance element 17 therefore varies so that a display circuit which is shown at 18a, responds to a variation of resistance and is connected via cables 18 to the resistance element 17 delivers a signal which is perceptible by the driver. The resistance element 17 may also be designed as a simple piece of line which is to be interrupted.

Figure 3 shows a slave cylinder 3 of similar design to Figure 2 in which a piston 13 is axially movably arranged in a casing 10. The piston is sealed from the casing 10 via seals 14 and forms a pressure chamber 31 in a known manner. The pressure chamber is connected to the pressure line 9 via a connection 20. A bias spring 15 is also provided. A switch 21 which is inserted into the casing 10 and is actuated by the, for example conical, external contour of the piston 13 at the appropriate state of wear of the friction linings, penetrates into the pressure chamber 31 radially from the exterior. The switch is provided via cables 18 with a display circuit 18a which draws the driver's attention to the state of wear.

Figure 4 shows a slave cylinder 3 of the design already described, in which two contact pins 22 which extend parallel to one another and in the axial direction of the slave cylinder 3 are arranged in an insulated manner in the wall of the casing 10 opposite the piston 13.

These contact pins are provided via cables 18 with a display circuit. If these contact pins are appropriately arranged, they come into contact with the electrically conductive end wall of the piston 13 in the maximum wear position of the friction clutch and are therefore electrically interconnected. A piston 13 produced from metal may be used

or also a metallic coating of the end wall in the case of a plastics piston.

The slave cylinder 3 according to Figure 5 adopts a different method of displaying the state of wear. In this arrangement, a pressure-operated switch 23 which is connected via cables 18 to a display circuit 18a, on the one hand, and two hydraulic lines, more specifically the pressure line 9 and a by-pass 25 on the other hand are attached to the pressure chamber 31 in the above-described slave cylinder. The two lines open independently of one another in the pressure chamber 31. A nonreturn valve 26 having the function of a residual pressure valve is arranged in the pressure line 9 and a nonreturn valve 27 in the by-pass 25. The two valves 26 and 27 are arranged so as to act in opposite directions and the by-pass 25 is connected to the pressure line 9 on the side of the two valves remote from the pressure chamber 31. During release of the clutch, the pressure medium flows from the master cylinder 2 via the pressure line 9 and via the by-pass 25 through the nonreturn valve 27 into the pressure chamber 31. During engagement of the clutch, the pressure medium flows from the pressure chamber 31 via the nonreturn valve 26 back into the pressure line 9. Owing to its spring bias, the nonreturn valve 26 provides for a residual pressure in the pressure chamber 31. The piston 13 is now connected to a ram 24 which extends to the nonreturn valve 26 when the limit of wear of the friction linings is reached and loads it in the open position. The residual pressure maintained in the pressure chamber 31 is thus reduced to zero and this pressure drop may be displayed via the pressure-operated switch 23. In the present case, it is quite possible for the ram 24 to extend in the longitudinal direction of the piston movement and to penetrate the pressure chamber 31 and to act upon the nonreturn valve 26 arranged in this direction of movement.

The illustration of the two valves is only diagrammatic. Thus, for example, it is directly possible to incorporate the nonreturn valve 26 directly into the limiting wall of the casing 10 and not into one of the pressure lines illustrated. The same basically applies to the nonreturn valve 27. The two valves 26 and 27 are of conventional design and the valve bodies are held on their valve seat by spring bias until the valve body is lifted against the bias of the corresponding springs by the build-up of a pressure difference.

The co-operation between the clutch spring and the other components of the actuating system will be referred to briefly at this juncture, and this basically applies to all existing constructions. The spring 1c arranged in the friction clutch 1, for producing the pressing force for fixing the friction linings acts during clutch actuation against the force exerted on the master cylinder 2. During the engagement process of the friction clutch 1, this force of the clutch spring 1c ensures that all components are moved back into their original position. The same applies to the bias spring 15 which, on the one hand, ensures that the releasing device 6 rests without play on the corresponding release parts of the clutch even in the engaged state of the friction clutch, the force of the bias spring 15 however being considerably lower in each case than the force of the clutch spring 1c.

Figure 6 shows a slave cylinder 4 which is arranged concentrically round the gear shaft shown at 1b, more specifically in the immediate vicinity of the release parts of the friction clutch 1. In the present case, this slave cylinder 4 consists of a two-part casing 30 which forms an annular chamber for the axial movement of an annular piston 28. This annular piston 28 forms, with the annular chamber of the casing 30, a pressure chamber 31 with respect to which the annular piston 28 is sealed via a seal 14. The casing 30

as well as the annular piston 28 are arranged concentrically to an axis of rotation 46 which simultaneously represents the axis of rotation for the friction clutch and the gear shaft.

The radially internal casing part is provided with an axial projection 44 having a stop 44a for the annular piston 28. This stop serves to fix the annular piston 28 during assembly and when being filled with pressure medium. The casing 30 has a connection 20 to which the pressure line 9 is attached. The annular piston 28 has, in its region remote from the pressure chamber 31, a supporting plate 29 which extends radially outwardly and serves for axially supporting the release bearing 12. The non-revolving external ring 33 of the release bearing 12 rests on the supporting plate 29, and the revolving internal ring 35 points toward the actuating elements of the friction clutch. To release the clutch, the pressure chamber 31 is loaded with hydraulic pressure via the pressure line 9 so that the annular piston 28 travels out of the casing 30 in the direction of arrow F so the release bearing 12 can actuate the clutch. The casing 30 is rigidly secured to the gear casing (not shown). An axially acting bias spring 15 of which the action is already known from the other constructions is arranged between the casing 30 and the supporting plate 29. The radially external casing part 30 also has an axial projection 43 which extends at the appropriate radial distance from the axial projection 44 so as to receive the annular piston 28, this projection 43 being axially shorter in design to allow the axial movement of the supporting plate 29 with the release bearing 12. Contact pins 22 are arranged in an insulated manner on an annular carrier 22a in the radial chamber between the axial projection 43 and the bias spring 15, the contact pins 22 on the one hand being connected via cables 18 to the display circuit 18a and on the other hand extending axially parallel to the axis of rotation 46 toward the supporting plate 29. With increasing wear of the friction linings of the clutch

plate, the annular piston 28 moves with the release bearing 12 against the direction of arrow F toward the casing 30 and, when the limit of wear is reached, the supporting plate 29 touches the two contact pins 22 and therefore conductively connects them to one another. The display circuit 18a may be activated by this conductive connection between the two contact pins 22. The limit of wear is therefore signalled to the driver.

The present construction is based on a basically known release system which may be converted by simple means for displaying the state of wear of the clutch.

Figure 7 shows a slave cylinder 4 which is substantially equivalent to the slave cylinder according to Figure 6 with regard to its basic design. The casing 30 which is produced in one part in this case has an annular chamber which, together with an annular piston 28, forms a pressure chamber 31. The pressure chamber 31 is connected to the pressure line 9 via a connection 20. The annular piston 28 is guided with its seal 14 between the two axial projections 43 and 44, the radially internal projection 44 also extending in its complete axial length beyond the release bearing 12. In the present case, the annular piston 28 is produced, for example, from plastics material and the supporting plate 29 is poured into the plastics material. It receives the release bearing 12 and axially supports the non-revolving external ring 33 thereof. On the side of the supporting plate 29 remote from the release bearing 12 there is arranged a two-part dust sleeve 26 which extends axially movably radially and between the axial projection 43 and the bias spring 15. This dust sleeve 26 prevents the penetration of dirt into the sliding faces between the annular piston 28 and the axial projection 43. A displacement measuring sensor 37, for example in the form of an electric variable resistor or a digital displacement encoder, which extends axially at a radial

distance from the bias spring 15 is arranged on the casing 30 radially outside the bias spring 15. This sensor 37 is connected via cables 18 to an evaluating device 18a. The sensor 37 co-operates with a slider 38 arranged on the dust sleeve 56. The slider 38 therefore moves during the release or engagement movement together with the release bearing 12 relative to the stationary sensor 37. With this device it is possible to transmit both digital and analog signals via the cables 18 to the evaluating device 18a so that every relative position of the release bearing 12 with respect to the casing 30 can be detected exactly. Such a device is not only suitable for monitoring the state of wear of the friction clutch but can also be used for the automatic control of the friction clutch.

The signals derivable from the sensor 37 serve, via the appropriate evaluations of the evaluating device, for the automatic control of the clutch which may be provided instead of the clutch pedal 8.

In a variation of the construction shown in Figure 7, Figure 8 shows a slave cylinder 4 in which the displacement measuring device is integrated into the slave cylinder. The displacement measuring device detects the displacement signal by means of a capacitor arrangement of variable capacitance. For capacitance detection, the annular piston 28 is, on the one hand, produced from plastics material and, on the other hand, provided with an electrically conductive coating 32 on its external periphery. Furthermore, the annular piston 28 with its coating 32 has a gap optionally filled with dielectric material relative to the axial projection 43 so that the two parts do not touch one another. The metallic projection 43 of the casing 30 forms a capacitor of variable capacitance with the coating 32 of the piston 28. The coating and the projection are electrically separated from one another and are connected to an evaluating device 18a via

separate cables 18. Owing to the different axial overlap between the axial projection 43 and the coating 32 of the annular piston 28, the two parts act as a variable capacitor, more specifically the capacitance varies according to the relative position of release bearing 12 and casing 30. Thus, the respective position of the release bearing and the respective state of the engagement of the friction clutch may be detected exactly via the evaluating device. A particular advantage of this construction is that already existing components may be used for determining the relative movement. The construction is simple and strong as the components carrying out displacement measurement do not touch one another. The evaluating circuit 18a may comprise, for example, an oscillator, in particular a pulse oscillator, of which the frequency-determining circuit contains the capacitor. The oscillator frequency varying as a function of the capacitance may be measured for displacement measurement.

Figure 9 shows a slave cylinder 5 in which displacement measurement is also carried out without contact. The upper half of the illustration differs in certain points from the lower half.

As a basic difference from the constructions described hitherto, a slave cylinder intended for a so-called drawn friction clutch is provided here. With such a friction clutch, the release process takes place in that the release parts of the friction clutch are moved away from the friction clutch toward the slave cylinder. The release bearing 12 is therefore designed such that the revolving internal ring 36 can engage round the release elements of the friction clutch. To release the friction clutch, therefore, the release bearing 12 is moved from left to right in this case in the direction of the arrow F. The casing 30 of the slave cylinder 5 is also designed in two parts in the present case and it forms an annular chamber for the arrangement of the

annular piston 28. The pressure chamber 31 is arranged on the left-hand side of the annular piston 28 and, on the right-hand side, in the direction of arrow F, the annular piston 28 projects from the annular chamber and is positively connected to the end region 39 of the non-revolving external ring 34 of the release bearing 12. The casing 30 has, at its end region lying in the direction of arrow F, a fastening flange 53 with which the slave cylinder 5 is fastened on a gear casing. At the end region located against the direction of arrow F, the casing is provided with the connection 20 for the pressure line 9. The radially external casing part has an annular cylindrical internal contour 54 which serves to guide the annular piston 20 radially outwardly. The annular piston 28 is guided radially inwardly through an axial projection 55 of the casing 30 which is shorter in the direction of arrow F than the annular cylindrical internal contour 54. This allows the annular piston 28 to transmit its movement to the non-revolving external ring 34 of the release bearing 12. The axial projection 55 has, at its internal diameter, a bearing sleeve 57 which axially guides the external ring 34. The external ring 34 is provided in one part with a tubular portion 49 which has a continuous external diameter and is axially guided by it in the bearing sleeve 57.

The end region 39 of the tubular portion 49 which points away from the release bearing 12 in the direction of arrow F is positively connected to the end of the annular piston 28. The external ring 34 has a track for balls which allow a rotational movement for the internal ring 36. The internal ring 36 engages round the release elements of the friction clutch and is therefore capable of releasing the clutch during an actuation in the direction of arrow F. In the radial chamber between the tubular portion 49 and the axial projection 55 there is arranged the bias spring 15 which rests on the casing 30 on the one hand and on the annular

piston 28 on the other hand. Its role has already been described with respect to the preceding constructions. In the chamber radially inside the tubular portion 49 there is arranged in the present case an induction coil 47 (upper illustration) and 48 (lower illustration), which is held by a sheet metal carrier 50. This sheet metal carrier 50 rests radially on the annular cylindrical internal contour 54 of the casing 30 and is axially fixed by a radially extending collar 51 in a hollow 52 of the fastening flange 53. The induction coil 47 or 48 is connected in each case via cables 18 to an evaluating device 18a. The cylindrical induction coil 47 illustrated in the upper half of Figure 9 is arranged such that it opposes the end region 39 of the tubular portion 49 at a small radial distance. In the axial direction there is a different overlap between the two parts according to the respective state of engagement of the friction clutch. The design of the tubular portion 49 of a ferromagnetic material allows a smooth signal corresponding to the state of engagement of the friction clutch to be derived without contact by varying the induction in the induction coil 47. This method of displacement measurement is free from wear and may be used for automatic actuation of a friction clutch.

The lower half of Figure 9 shows a variation of an inductive displacement sensor. In contrast to the upper half, in which the tubular portion 49 has a cylindrical internal contour 40, the tubular portion 49 is provided with a conical contour 41 and the axial overlap between the tubular portion 49 and the induction coil 48 is guaranteed in each position in the lower half. In this case, the displacement information is derived from the radial gap between the conical internal contour 41 and the induction coil 48. Here also the variation of induction is a reliable gauge for determining the state of release of the friction clutch.

For detecting the displacement information, the evaluating device 18a can again comprise an oscillator, in particular a pulse oscillator, of which the frequency-determining circuit contains the inductors. The oscillator frequency which similarly varies with the overlap of the inductors 47 by the part 49 or with the varying distance and/or material cross section of the region of part 49 opposing the inductor 48 may be measured by means of a frequency measuring device, for example a counter counting pulses per unit time, and may be evaluated for displacement detection.

It goes without saying that a displacement sensor according to Figure 7 or 8 may also be used in a slave cylinder of a drawn clutch, in particular the cylinder according to Figure 9. On the other hand, the inductive displacement sensor according to Figure 9 may also be used in a slave cylinder of a pressed clutch, in particular the cylinder in Figure 7 or 8.

CLAIMS:

1. Friction clutch for a motor vehicle with a clutch plate (1e) which may be fixed between two components (1f, 1g) and rests non-rotatably on a gear shaft (1b), a clutch spring (1c) for fixing the clutch plate (1b) between the two components (1f, 1g), a clutch actuator with a clutch-side slave device (3; 4; 5), a clutch-remote master device (2) as well as an interposed transmission device (9), a displacement sensor being arranged in the clutch-side slave device (3; 4; 5), characterised by the following features:

a) the clutch actuator contains a fluid-actuated slave cylinder (3; 4; 5);
b) the displacement sensor (17; 21; 23; 22, 13; 22, 29; 32, 43; 37, 38; 47; 48) is arranged in or on the slave cylinder (3; 4; 5).

2. Friction clutch according to claim 1, characterised in that the slave cylinder (3) is arranged outside the clutch (1) and is connected via a release rod (release fork 7) to the releasing device (6) or in that the slave cylinder (4, 5) is combined with the release bearing (12) to form a unit which is arranged concentrically round the gear shaft (1b).

3. Friction clutch according to claim 2, characterised in that the displacement sensor is designed as a mechanical/ electrical limit switch (17; 21; 22, 13; 22, 29) or as a hydraulic pressure-operated switch (23) or as a displacement sensor (37, 38; 32, 43; 47; 48) for producing a smooth displacement signal or as a displacement sensor (37) for producing a digital displacement signal.

4. Friction clutch according to claim 3, characterised in that the displacement sensor is designed as a continuously variable resistor (37) or as a capacitor arrangement (32, 43) with continuously variable capacitance or as a coil

arrangement (40, 47; 41, 48) with continuously variable inductance.

5. Friction clutch according to claim 3, characterised in that the limit switch (17, 21, 22) is fastened on the casing (10, 30) of the slave cylinder (3, 4) and is actuated by a part (11, 13, 29) which is movable relative to the casing and communicates with the release system (piston rod 11, release bearing 12).

6. Friction clutch according to claim 5, characterised in that the limit switch is designed as an exchangeable resistance element (17) which is connected to a display circuit (18a) and is destroyed by the movable part (11) when the limit of wear is reached.

7. Friction clutch according to claim 6, wherein the slave cylinder (3) is designed as a component which is separate from the releasing device (6) and comprises a cylindrical casing (10), a piston (13) capable of moving in the casing (10) and a piston rod (11), characterised in that in the region of emergence of the piston rod (11) from the casing (10) there is arranged on the casing (10) an annular disk-shaped resistance element (17) of which the opening is penetrated by the piston rod (11) and in that the piston rod (11) is provided with a diametral enlargement which forms an edge (19) and destroys the resistance element (17) in a predetermined wear position.

8. Friction clutch according to claim 7, characterised in that the resistance element (17), at least in part, has a curved external contour corresponding to a hollow (45) in the casing (10) and is held between a step and a securing ring (16) on the casing (10).

9. Friction clutch according to claim 5, wherein the slave cylinder (3) is designed as a component which is separate from the releasing device (6) and comprises a cylindrical casing (10), a piston (13) capable of moving in the casing (10) and a piston rod (11), characterised in that the piston (13) actuates the limit switch (21, 22) directly.

10. Friction clutch according to claim 9, characterised in that the limit switch (21, 22) extends directly into the pressure chamber (31) formed between piston (13) and casing (10) and is actuable by the end region of the piston (13) facing the pressure chamber (31).

11. Friction clutch according to claim 10, characterised in that the limit switch (21) is inserted tightly into the cylindrical casing (10) radially from the exterior and penetrates into the pressure chamber (31).

12. Friction clutch according to claim 10, characterised in that the limit switch is formed in the shape of two contact pins (22) which are arranged in parallel and are insulated in the wall which is axially opposed to the piston (13) and seals the pressure chamber (31), extend toward the piston (13), are connected to a display circuit (18a) and may be conductively interconnected by the electrically conductive surface of the piston (13).

13. Friction clutch according to claim 3, wherein the slave cylinder (3) is designed as a component which is separate from the releasing device (6) and comprises a cylindrical casing (10), a piston (13) capable of moving in the casing (10) and a piston rod (11), characterised in that into the pressure chamber (31) formed by the casing (10) and piston (13) there extends a hydraulic pressure-operated switch (23) as well as two pressure lines (9, 25) connected to the slave cylinder (2), a nonreturn valve (26, 27) being arranged in

each pressure line, more specifically so as to act in opposite directions, one nonreturn valve being designed as a residual pressure valve (26) with a closing function during clutch release, which nonreturn valve may be brought into the open position during the engagement movement by contact with the piston (13, 24), so as to display the residual pressure drop by the pressure-operated switch (23).

14. Friction clutch according to claim 5, wherein the slave cylinder (4) is arranged concentrically round the gear shaft (1b), has an annular piston (28) which is capable of moving in an annular chamber of a cylinder casing (30) and carries a release bearing (12) on the side remote from the pressure chamber (31), characterised in that on the casing (30) of the slave cylinder (4) there are arranged two insulated contact pins (22) which extend parallel to the axis of rotation (46), are connected to a display circuit and may be brought to rest on electrically conductive parts of the release bearing (12) or its mounting (29) on the annular piston (28).

15. Friction clutch according to claim 4, wherein the slave cylinder (4; 5) is combined with a release bearing (12) to form a unit which is arranged concentrically round the gear shaft (1b), an annular piston (28) is axially movably arranged in an annular chamber of a casing (30) of the slave cylinder (4; 5) and forms a pressure chamber (31) therewith, characterised in that the inductive or capacitive displacement measuring sensor measures the change of inductance or capacitance on the basis of an overlap between the piston (28) or a component (49) functionally connected to the piston (28), on the one hand, the overlap being variable according to the state of release of the clutch, and a component (47, 48) which is rigid with the casing on the other hand.

16. Friction clutch according to claim 15, characterised in that the piston (28) consists of an electrically non-conductive material, is provided with an electrically conductive layer (32) on its external periphery and is at a distance from the internal contour (42) of an axial projection (43), consisting of metal at least at the adjacent face, of the casing (30) and in that the piston (28) has a partial overlap relative to the axial projection (43) forming the internal contour and, between its external periphery and the internal contour (42) forms a capacitor with capacitance which is variable according to the release movement of the clutch.

17. Friction clutch according to claim 15, characterised in that as a component which is rigid with the casing there is provided an induction coil (47; 48) which is axially overlapped to different extents according to the state of release by a ferromagnetic component (29) of cylindrical contour (40) such that the change of induction is a gauge of the release path or which is axially overlapped by a ferromagnetic component (49) having a conical contour (41) such that the radial distance between induction coil (48) and the ferromagnetic component (49) is a gauge of the release path.

18. Friction clutch according to claim 17, wherein the slave cylinder (5) is provided for drawn clutch actuation, characterised in that the ferromagnetic component with the cylindrical contour (40) or conical contour (41) is designed as a tubular portion (49) which is connected to the annular piston (28) in the region of one of its ends and of which the opposite end region has an antifriction bearing track of the release bearing (12).

19. Friction clutch according to claim 18, characterised in that the induction coil (47, 48) is fastened on a sheet metal

carrier (50) which is radially fixed on an annular cylindrical internal contour (54), serving to guide the annular piston, of the casing (30), the sheet metal carrier (50) being axially fixed by a radially angled collar (51) in a hollow (52) of a fastening flange (53) of the casing.

20. Friction clutch according to claims 7 or 8, wherein the slave cylinder (4) is combined with a release bearing (12) to form a unit which is arranged concentrically round the gear shaft (1b), an annular piston (28) is axially movably arranged in an annular chamber of a casing (30) and forms a pressure chamber (31) therewith, wherein a radial flange (29) is arranged on the end, remote from the pressure chamber (31), of the piston (28) to support a non-revolving bearing ring (33) of the release bearing (12), on the one hand, and a bias spring (15) on the other hand, supported on the casing (30), characterised in that radially outside the bias spring (15) on the casing (30) there is fastened a sensor (37) which extends axially in the direction of the release bearing (12) and in that on the flange (29) there is arranged a slider (38) which performs a relative movement with respect to the sensor (37) according to the release movement of the piston (28).

21. Friction clutch according to claim 20, characterised in that the casing (30) has an axial projection (43) for guiding the annular piston (28) on the radially outer side thereof, in that the axial projection (43) is provided on its external periphery with a dustproof sleeve (56) which, on the release bearing side, is fastened on the supporting plate (29), has a contact face for the bias spring (15) and carries the slider (38) at a radial distance from the bias spring (15).

22. Friction clutch substantially as described with reference to the accompanying drawings.

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Relevant Technical fields

(i) UK Cl (Edition K) F2L: LK

(ii) Int Cl (Edition 5) F16D 25/08

Databases (see over)

(i) UK Patent Office

(ii)

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10 SEPTEMBER 1992

Documents considered relevant following a search in respect of claims 1-22

Category (see over)	Identity of document and relevant passages		Relevant to claim(s)
X	GB 2182410 A	(AUTOMOTIVE PRODUCTS) See 32, Figures 1-6; 110 Figure 8; line 45 page 3; lines 78-80 and lines 126-130 page 5; line 3, page 6; Figure 13.	1-5, 9-11 14-18 and 20
X	GB 2164494 A	(AUTOMOTIVE PRODUCTS) See Figure 2	1, 3, 9 and 10
X	GB 2163292 A	(AUTOMOTIVE PRODUCTS) See Figures 1 and 3	1, 3, 9 and 10
X	GB 2105880 A	(AUTOMOTIVE PRODUCTS) See 13, Figure 1; lines 14 and 65, page 1.	1-3
X	GB 1169479	(TEL-LIFE CORP) See 45, Figures 1 and 2; lines 13 and 14, page 1.	1-3, 9-11

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Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

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